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CONTENTS

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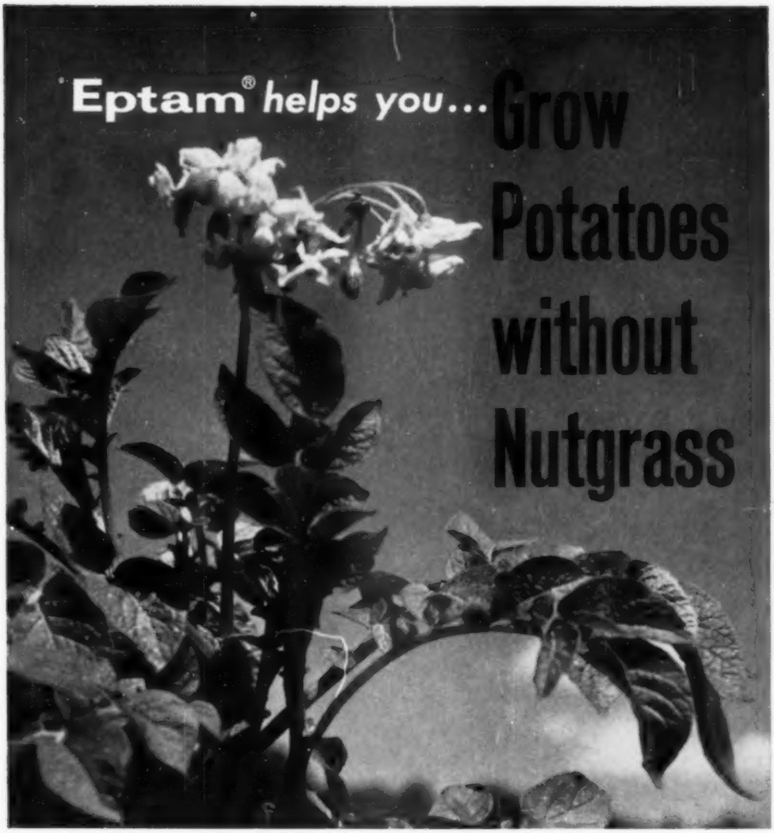

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RESPONSE OF POTATOES TO DIFFERENT AMOUNTS OF NITROGEN, PHOSPHORIC ACID AND POTASH WHEN GROWN IN CONTINUOUS CULTURE AND IN ROTATION WITH REDTOP[1]

T. E. Odland, and J. E. Sheehan[2]

An experiment was begun at the Rhode Island Agricultural Experiment Station in 1944 to obtain information on the effect of various amounts and ratios of fertilizer materials on yield and quality of potatoes. A paper was published in 1956 (4) reporting the results obtained during the first 10 years of the experiment. This experiment was discontinued after the 1958 harvest.

In this paper, results obtained during the 14 year period will be summarized. It will include data from part of the work not previously reported. Results from another rotation experiment where soybeans were alternated with potatoes will also be presented.

In 1951, each plot was divided into 2 sections. On the west half of each plot a rotation of 2 years of potatoes and 2 of redtop was begun. On the east half potatoes were grown continuously during the 14 year period.

During the first 10 years little response was obtained to increased rates of phosphorus or potassium in the fertilizer. This was because potatoes, with heavy fertilizer applications, had been grown on this area for a number of years before the experiment had begun.

Results with varying amounts of nitrogen were different. When the nitrogen amount was increased from 60 to 120 pounds per acre in various steps, the yields increased. However, there was little increase with applications beyond 90 pounds of nitrogen per acre.

Increasing the amounts of a 6-12-12 fertilizer from 1250 pounds per acre to 2500 pounds resulted in no increase in yield beyond the 2000-pound application. Later, when the fertilizer grade was changed to an 8-12-12, there was no response beyond 1750 pounds per acre of this fertilizer.

It was concluded that the N, P_2O_5, and K_2O in the fertilizer for potatoes under these conditions should be gradually changed from the customary 1-2-2 to one approaching a 1-1-1 ratio for continuous potato culture. An application of 1500 to 2000 pounds per acre of an 8-12-12, 10-10-10, or similar fertilizer, would probably supply all the nutrients needed by the potato crop.

Materials and Methods

A previous publication describes the details of how the experiment was conducted (4). Only a brief review will be included here. The soil on which the experiment was located is classified as a Bridgehampton silt loam and has a pH of approximately 5.2. It was in a high state of fertility when the work was begun. Application rates ranged from 1250 to 2500

[1]Accepted for publication June 30, 1960. Contribution No. 1007 of the Rhode Island Agricultural Experiment Station, Kingston, R. I.

[2]Professor and Chairman, Department of Agronomy and Assistant Professor of Agronomy, respectively. This experiment was planned and begun by A. E. Rich who is now Plant Pathologist at the New Hampshire Experiment Station.

pounds per acre of a 6-12-12 fertilizer. This changed to rates of 1000 to 2250 pounds per acre of an 8-12-12 grade in 1951. Beginning in 1950, an annual application af 200 pounds per acre of cyanamid was made to a rye cover crop in the spring before plowing.

Magnesium was added in all potato fertilizers to supply 40 pounds per acre of MgO. Muriate was used as the potash source in the early years of the experiment. Since 1951, only sulfate of potash has been used.

In the ratio study, nitrogen was varied from 60 to 150 pounds per acre. The range in P_2O_5 was from 90 to 225 pounds per acre throughout the entire period and K_2O ranged from 135 to 270 pounds per acre. Since 1950, these plots also have received 200 pounds per acre of cyanamid applied to the cover crop in the spring.

All plots were split crosswise in 1951. One-half (W½) was put into a rotation of 2 years redtop and 2 years of potatoes. The other half (E½) remained in continuous potatoes. Potatoes were grown on the rotation areas (W½) in 1953, 1954, 1957, and 1958.

Green Mountain potatoes were grown during 1945-53 and Katahdin during 1954-58. Yields per acre and specific gravity of the tubers were determined. Samples were kept in storage for determination of keeping qualities. At various times, samples of tubers from selected plots were used also in cooking quality studies.

Redtop was clipped several times during the season and left on the ground. An annual fertilizer application of 500 pounds per acre of an 8-12-12 was used on redtop in this rotation.

During 1946 to 1954 potatoes were also grown in a two-year rotation with soybeans as a green manure crop in alternate years. This rotation was located on an adjoining field. Soybeans were planted in late May following a rye cover crop and was disked in as green manure in mid-July. Then, another crop of soybeans was planted. This second crop was disked in about mid-September and a rye cover crop planted. This rotation was compared with continuous potatoes grown in adjacent plots. Potatoes and soybeans in this rotation received 1800 and 750 pounds per acre, respectively, of an 8-12-12 fertilizer.

Results

The yields of potatoes have varied considerably from year to year, depending largely on the amount and distribution of rainfall. In 4 years out of 14, rainfall was insufficient and yield was reduced. In one year, 1954, a hurricane destroyed the vines on September 1 before growth was complete. During the other 9 years, very satisfactory yields were obtained.

Fertilizer amounts

Table 1 presents the yields obtained with various amounts of a standard 8-12-12 fertilizer. Average yields of 4 replicates each year are given for the years, 1951-1958; the averages for the 4 years, 1953, 1954, 1957, and 1958; and the averages for 1945-1958 for the continuously grown potatoes. On the West ½ where potatoes were grown only 4 years out of the 8 since 1951, the average yields for 1951-1958 would not be comparable to those where the crop is grown every year. Therefore, the comparison in yields will be made only for the four years when they appear in the rotation—1953, 1954, 1957, and 1958.

TABLE 1.—*Yields of potatoes with different amounts of fertilizer at the Rhode Island Agricultural Experiment Station, 1945-1958*

Lbs./A 8-12-12*	Bushels per acre, U. S. No. 1								Averages		
	Continuous potatoes (E½)									53-54	
	1951	1952	1953	1954	1955	1956	1957	1958	51-58	57-58	45-58
1000	373	213	357	214	455	448	274	371	338	304	332
1250	386	212	376	198	423	466	276	411	344	315	339
1500	384	231	386	272	487	520	299	442	378	350	361
1750	360	194	370	257	451	517	296	411	357	334	355
2000	383	210	383	269	478	562	307	411	376	343	368
2250	345	183	366	292	471	514	293	431	362	346	359
Average	372	207	373	250	461	505	291	413	359	332	352
LSD at .05									20	30	13
	Redtop-potato rotation (W½)										
1000	..	..	477	284	..	..	365	410		384	
1250	..	..	496	267	..	..	371	434		392	
1500	..	..	482	311	..	..	402	413		402	
1750	..	..	494	330	..	..	394	438		414	
2000	..	..	484	312	..	..	374	449		405	
2250	..	..	504	356	..	..	367	460		422	
Average			490	310			378	434		403	
LSD at .05										30	

*Previous to 1951 a 6-12-12 fertilizer was used. The rates were 250 pounds more per acre in each amount; thus making a range from 1250 to 2500 pounds per acre. Beginning in 1950, 200 pounds per acre of calcium cyanamid were applied to the rye cover crop before plowing in the spring.

In considering average yields on the continuously grown potatoes for 1951-1958, there was no significant increase in yields when the fertilizer application was increased from 1000 pounds of 8-12-12 per acre to 1250 pounds. When this was increased to 1500 pounds, an average increase of 40 bushels per acre was obtained. No further increases in average yields were obtained with amounts above 1500 pounds per acre. The same applies when averages for 1953, 1954, 1957, 1958 or for 1945-1958 are considered.

In considering potato yields in the rotation, there was a higher yield obtained in nearly every instance when potatoes followed redtop than where potatoes were grown continuously, regardless of the fertilizer amount used. The average yield for all treatments for 1953, 1954, 1957, and 1958 in the redtop rotation was 403 bushels per acre compared with 332 bushels where potatoes were grown continuously. Generally, potato yields showed the most benefit the first year following redtop. In 1953 the average yields of all plots following redtop was 490 bushels and only 373 bushels on the continuous potato plots. In 1954 there was a difference of only 60 bushels. However, yields were low on both series of plots on account of the abbreviated season caused by the hurricane on September 1 of that year.

There was a small but consistent increase in yields when fertilizer was increased to 1,750 pounds per acre where potatoes were grown in rotation with redtop.

In 1957, a very dry year, the yields were again low, but an average increase of 87 bushels per acre was obtained following redtop compared

to continuous potatoes. The average yield following redtop was 378 bushels per acre and on the continuous potato plots, 291 bushels. In 1958, which was an exceptionally wet year, excellent yields were obtained on all plots regardless of treatment. The average yield for all treatments on continuous potato plots was 413 bushels per acre and on the redtop rotation, 434 bushels.

In other experiments at this Station (5, 6), redtop has proved very beneficial as a crop to grow in rotation with potatoes. Redtop sod has usually produced 50 to 100 more bushels of potatoes per acre than has land in continuous potatoes. Redtop has been more effective than clover, timothy, or various mixtures of timothy and clover. Both alsike and red clover have been used.

Fertilizer ratios

Table 2 shows potato yields on the plots where various fertilizer ratios were compared. Averages have been computed for years grouped in the same manner as for the comparisons of different rates of a standard grade fertilizer.

Considering the average yield for the 1951-1958 period on the half with continuous potatoes (E½), the range is from 326 bushels per acre produced with low phosphorus (8-6-12) to 367 bushels with 8-12-12. There was no increase in potato yields from increased amounts of nitrogen in the fertilizer. The average yield with 1500 pounds of 6-12-12 was 356 bushels; with 1500 pounds of 8-12-12, 367 bushels; and with 10-12-12 it was 353 bushels. Note that approximately 40 pounds of nitrogen per acre was applied also to the rye cover crop in cyanamid. Therefore, the total amount of nitrogen applied in the fertilizers for the season amounted to 130, 160, and 190 pounds per acre for the various nitrogen ratios. This compares with 60, 90, and 120 in the first years of the experiment when a very definite response was obtained to additional nitrogen in the fertilizer. The minimum amount of nitrogen applied since 1951 was somewhat higher than the maximum for the earlier period.

The amounts of phosphorus and potassium applied were not changed since the experiment was begun, because no increases in yield had resulted with additional amounts of these ingredients over the minimum during the early years of the tests. Apparently, there were large residual amounts of both materials from previous fertilizer applications.

Average yields with low, medium, and high rates of phosphorus for the period 1951-1958 on the continuous potatoes were 326, 336, and 351 bushels per acre, respectively. There was no increase in yields when potash was increased from 135 to 270 pounds per acre. Apparently, there was enough residual potash in the soil to supply all the nutrient needs of the crop with the minimum amount applied.

In comparing the various rates on continuous potatoes, with those in the redtop rotation, the same general increase in yields was obtained following redtop as was found in the amounts of fertilizer comparison. Average yield for all treatments on the continuous potatoes was 325 bushels per acre and 404 bushels on the redtop rotation. Responses to N, P, and K were similar under the two conditions—none to N, significant response beginning to show with P, and none to increasing the K. There

TABLE 2.—*Yields of potatoes with different ratios of fertilizer at the Rhode Island Agricultural Experiment Station, 1945-1958.*

Treatment	Lbs./A*			Bushels per acre U. S. No. 1 potatoes — Continuous potatoes (E½)								Averages		
	N	P_2O_5	K_2O	1951	1952	1953	1954	1955	1956	1957	1958	51-58	53-54 57-58	45-58
Low N	90	180	180	357	186	395	242	458	482	289	436	356	341	318
Med. N*	120	180	180	361	188	357	260	499	530	335	405	367	339	354
High N	150	180	180	364	182	338	260	454	497	301	425	353	331	354
Low P_2O_5	120	90	180	386	152	344	185	416	465	272	390	326	298	325
Med. P_2O_5	120	135	180	385	172	326	248	431	451	261	412	336	312	329
High P_2O_5	120	225	180	358	148	360	246	495	471	299	432	351	334	343
Low K_2O	120	180	135	370	168	340	227	476	484	305	439	351	328	343
Med. K_2O	120	180	225	363	164	343	229	468	473	288	424	344	321	338
High K_2O	120	180	270	352	150	333	240	433	480	277	424	336	319	332
Average				366	168	348	237	459	481	292	421	347	325	337
LSD at .05												18	25	14
				Redtop-potato rotation (W½)										
Low N	90	180	180	..	..	469	322	..	..	369	456		404	
Med. N*	120	180	180	..	..	467	326	..	..	405	422		405	
High N	150	180	180	..	..	428	321	..	..	369	452		392	
Low P_2O_5	120	90	180	..	..	470	270	..	..	327	444		378	
Med. P_2O_5	120	135	180	..	..	440	313	..	..	359	428		385	
High P_2O_5	120	225	180	..	..	492	366	..	..	403	466		432	
Low K_2O	120	180	135	..	..	455	350	..	..	412	467		421	
Med. K_2O	120	180	225	..	..	481	332	..	..	357	471		410	
High K_2O	120	180	270	..	..	473	331	..	..	359	459		406	
Average						464	326			373	452		404	
LSD at .05													24	

*This is the equivalent of 1500 pounds per acre of a 9-12-12 fertilizer. Previous to 1951 the N amounts were 60, 90, and 120 pounds per acre on the low, medium, and high N ratios respectively. Beginning in 1950 an application of 200 pounds per acre of calcium cyanamid were applied to the rye cover crop before plowing in the spring.

were considerable variations between the different seasons. In 1954 the additional phosphorus in the fertilizer showed excellent results. Where 90 pounds of P_2O_5 was used (1500 lbs. 8-6-12), the yield was only 270 bushels per acre. This increased to 313 bushels and to 366 bushels when 135 pounds and 225 pounds were used (1500 of 8-15-12).

In the extremely dry season, 1957, there was also a strong response to phosphorus. On the redtop rotation the yield increased from 327 bushels with 90 pounds per acre of P_2O_5 to 403 bushels when 225 pounds were applied. On the continuous potato plots there was considerably less response to the additional phosphorus in the fertilizer.

No significant increase in potato yield resulted with additional potash on the redtop rotation except in 1953 when there was an increase from an average of 455 bushels per acre where 135 pounds were applied to 481 bushels where 225 pounds were applied. No increases were obtained in any year with continuous potatoes when more than the minimum of 135 pounds were used. There was a tendency for lower, rather than higher yields, with the use of additional potash.

Soybean-Potato Rotation

Table 3 shows potato yields obtained in the soybean-potato rotation. This experiment was discontinued in 1954; therefore, only 9 potato crops are represented.

Average yields were 336 bushels of U. S. No. 1 potatoes on the continuous potato plots and 393 bushels where they were grown in rotation with soybeans. There was a small difference in yield every year in favor of the rotation. The soybeans required considerably more work and other expense than did redtop and were less effective in increasing potato yields.

Table 3.—*Yields of potatoes in a 2-year potato-soybean rotation and in continuous culture at the Rhode Island Agricultural Experiment Station, 1945-1954.*

Treatment	Bus. per acre—U. S. No. 1									Average
	1946	1947	1948	1949	1950	1951	1952	1953	1954	
Continuous potatoes	417	337	298	198	327	395	256	362	395	336
Potato-soybean rotation	469	437	341	265	386	426	328	473	409	393
Average	443	407	320	232	356	411	292	418	402	364
LSD at .05										26

Specific Gravity of Potato Tubers

Table 4 presents the specific gravity of the potatoes from the fertilizer amounts study. The yearly figures are the average of the four replicates for the treatment. The first two figures for each entry, 1.0, have been omitted for brevity. In most cases a difference of .002 in specific gravity (2 in the Table figures) is significant.

The specific gravity varied considerably from year to year. Averages on the continuous potato plots varied from 1.057 in 1955 to 1.074 in 1956.

Since Green Mountain potatoes were grown before 1954, the first 3 years in the tabulation is from this variety. Beginning with 1954 the Katahdin variety was used. Green Mountains have generally been a little higher in specific gravity than Katahdins in the varietal tests of potatoes at this Station (7). In this experiment the effect of the various treatments on specific gravity of the potatoes has been very similar on the two varieties and the data have been averaged regardless of variety.

The average specific gravity for potatoes grown in rotation with redtop varied from 1.066 in 1954 to 1.078 in 1953. In each of the 4 years where a comparison was possible with the same treatments under continuous culture the specific gravity was appreciably higher in potatoes grown in rotation with redtop. Note that yields also were higher in the rotation.

For 1951-1958 period the highest average specific gravity was 1.069 from the plots with the lowest amount of fertilizer at 1000 pounds per acre. The highest application, 2250 pounds per acre, produced potatoes with the lowest specific gravity, 1.063.

Where comparisons of continuous versus rotation effects are possible in 1953, 1954, 1957, and 1958, the same tendency is noted for a decrease

TABLE 4.—*Specific gravity of potatoes from fertilizer amounts experiment at the Rhode Island Agricultural Experiment Station, 1951-1958.*

Lbs./A 8-12-12	Specific gravity with first 2 figures (1.0) omitted								Averages	
	Continuous potatoes (E½)									
	1951	1952	1953	1954	1955	1956	1957	1958	51-58	53-54 57-58
1000	76*	66	70	61	61	77	70	72	[illegible]	68
1250	74	61	72	61	57	75	68	70	67	68
1500	68	60	72	62	59	75	72	70	67	69
1750	67	60	69	60	56	73	67	68	65	66
2000	68	57	68	60	57	74	67	70	65	66
2250	63	56	65	59	51	72	68	69	63	65
Average	69	60	69	61	57	74	69	70	66**	67
	Redtop-Potato rotation (W½)									
1000	..	..	81	67	..	..	73	74		74
1250	..	..	79	66	..	..	72	74		73
1500	..	..	78	66	..	..	72	75		73
1750	..	..	77	64	..	..	72	72		71
2000	..	..	76	66	..	..	72	72		72
2250	..	..	75	64	..	..	69	71		68
Average			78	66			72	73		72

*Actual specific gravity is 1.0 + 76 or 1.076, etc. **LSD 1.5 (Actual 0.0015) at .05
Green Mountain variety grown 1951-1953, Katahdin 1954-1958.

in specific gravity with increasing rates of fertilizer application. This is the case both on the continuous and rotation crops. The average for the various amounts was considerably higher in potatoes in the redtop rotation than in the continuous potatoes—1.072 as against 1.067.

In the fertilizer ratio study, the same variation in specific gravity from year to year was obtained (Table 5). The range covered was approximately the same.

In considering the averages for 1951- 1958 for continuous potatoes, the low, medium, and high nitrogen treatments produced the same average, 1.066. There was no change in specific gravity when nitrogen was increased in the fertilizer from 90 to 150 pounds per acre. Murphy and Gowen (1, 3) found that under Maine conditions, when nitrogen was increased in various steps from 90 to 210 pounds per acre, there was a definite decrease in specific gravity. They now recommend rates of 150 pounds of nitrogen or less, for Katahdins for the production of potatoes of acceptable specific gravity.

The effect on specific gravity from increasing phosphorus in the fertilizer was inconsistent on the continuous potato plots. Average specific gravity for 1951-1958 was 1.065 where the lowest amount was used. There was a small decrease in specific gravity when the amount of phosphoric acid was increased from 90 pounds per acre to 135 pounds. When the amount of phosphoric acid was further increased to 225 pounds per acre, there was a definite increase in specific gravity — 1.063 on the medium to 1.067 on the high phosphoric acid. Why this variation should occur is not clear from the data.

Data from the potatoes grown in rotation with redtop indicate that, as phosphorus was increased, there was a small but consistent increase

TABLE 5.—*Specific gravity of potatoes from fertilizer ratio experiment at the Rhode Island Agricultural Experiment Station, 1951-1958.*

Treatment	Specific gravity with first 2 figures (1.0) omitted								Averages	
	Continuous potatoes ($E\frac{1}{2}$)									
	1951	1952	1953	1954	1955	1956	1957	1958	51-58	53-54 57-58
Low N	73*	58	65	60	57	74	66	72	66	66
Med. N	71	60	66	61	57	71	68	70	66	66
High N	72	59	65	62	56	75	67	69	66	66
Low P_2O_5	71	57	66	60	53	74	68	68	65	66
Med. P_2O_5	70	56	64	58	53	74	64	68	63	64
High P_2O_5	70	60	68	64	56	76	69	70	67	68
Low K_2O	74	58	69	64	56	75	70	71	67	68
Med. K_2O	70	57	63	60	55	75	67	69	64	65
High K_2O	68	57	65	56	51	73	64	69	63	64
Average	71	58	66	61	55	74	67	70	65**	66
	Redtop-Potato rotation ($W\frac{1}{2}$)									
Low N	..	..	78	61	..	..	72	69		70
Med. N	..	..	76	64	..	..	73	71		71
High N	..	..	74	65	..	..	70	70		70
Low P_2O_5	..	..	73	62	..	..	70	69		68
Med. P_2O_5	..	..	75	63	..	..	71	69		70
High P_2O_5	..	..	79	64	..	..	72	70		71
Low K_2O	..	..	75	65	..	..	74	72		72
Med. K_2O	..	..	78	61	..	..	72	69		70
High K_2O	..	..	70	60	..	..	69	66		66
Average	..	..	75	63	..	..	72	69		70

*Actual specific gravity is 1.0 + 73 or 1.073.
**LSD 1.5 (Actual 0.0015) at .05.

in specific gravity in the potatoes. There was a similar increase in yields when phosphorus was increased.

On both the continuous potato and rotation plots there was a consistent decrease in specific gravity of the tubers when potash in the fertilizer was increased. In Maine, it was also found that specific gravity of potatoes decreased when potash was increased (2, 3).

As in the fertilizer amounts series, the specific gravity of potatoes following redtop was consistently higher than in potatoes grown continuously.

Specific gravities were determined also on potatoes grown in a two-year rotation with soybeans. There was no consistent difference in specific gravity between potatoes grown in continuous culture and in rotation with soybeans. In continuous culture the specific gravity averaged 1.072 and in rotation with soybeans 1.073.

DISCUSSION

The area used in this experiment was typical of many Rhode Island potato farms. The soil was in a high state of fertility when the experiment was begun. As a result, there was no response from additions of phosphorus or potash to the minimum amounts used during the first 10 years of the experiment. This continued to be the same with potash until the

test was concluded at the end of 14 years. The phosphorus, however, was beginning to become depleted and a response to additional phosphorus was beginning to become evident.

During the first 5 years of the experiment when a 6-12-12 fertilizer which is relatively low in nitrogen, was used as the standard, there were definite increases in yield with additional nitrogen in the fertilizer. When the standard was changed to an 8-12-12 in 1951 and extra nitrogen added in cyanamid, further increases in yield were not obtained with more nitrogen. A better balance had been accomplished among nitrogen, phosphorus, and potash in fertilizer mixtures than was the case at the beginning of the experiment.

During the early period when 6-12-12 was used, it required about a ton of fertilizer per acre to produce the maximum yield. When this was changed to an 8-12-12 and 40 pounds additional nitrogen was applied in cyanamid, it required only 1,500 pounds per acre to reach maximum yields. This clearly shows the importance of providing the correct balance in a fertilizer to get maximum returns for the fertilizer dollar invested. Many potato growers who use a ton or more of fertilizer per acre could probably save considerably on their fertilizer bill by adjusting the fertilizer more to the needs of the crop and using less per acre.

Soil type, previous fertilizer practices, crop rotation, variety grown, and the purpose for which grown are factors that must be taken into consideration in deciding on the best amount and grade of fertilizer for potatoes. This experiment was located on an excellent potato soil. On a sandier and more open soil, the fertilizer application could probably have been increased to advantage. More fertilizer will be needed also when new land or land that has previously received only light fertilizer applications is used for potatoes. It is difficult to recommend a certain amount or kind of fertilizer for potatoes without taking into account the specific conditions on the individual farm where the crop is being grown. Experiments of this kind can provide only general information that has to be modified to fit any particular situation. In all cases, yearly soil tests should be made and results taken into consideration when deciding on the kind and amount of fertilizer to use for potatoes.

From all the data presented it would seem that an application of 1,500 to 1,800 pounds of an 8-12-12 or similar fertilizer would meet the requirements generally for a potato crop under these conditions.

Summary

In these experiments various amounts of a standard fertilizer were compared as well as a standard amount of different grades having various ratios of N, P, and K. Potatoes grown continuously and in rotation with redtop or soybeans were compared.

Green Mountain and Katahdin varieties were used, yields were determined, and data on specific gravity and cooking qualities obtained.

No significant increase in yield of potatoes was obtained when the fertilizer application was increased beyond 1,500 pounds per acre of an 8-12-12 where potatoes were grown continuously. When grown in rotation with redtop, increases in yield were obtained up to 1,750 pounds per acre of the same fertilizer.

No further increase in average potato yields was obtained when more than 130 pounds of nitrogen per acre were applied, including 40 pounds N in cyanamid.

Yields of potatoes were increased when the amount of phosphorus in the fertilizer was increased to 180 pounds of P_2O_5 per acre. No further increase in yield resulted when the amount was increased to 225 pounds per acre. The response to phosphorus was influenced considerably by seasonal weather conditions.

No increase in average yields of potatoes resulted from applications of more than 135 pounds per acre of potash.

The yields of potatoes, when grown in rotation with redtop, were usually 60 to 80 bushels more per acre than when they were grown continuously. The season and whether it was the first or second crop of potatoes, following redtop, had considerable influence on the results.

Growing potatoes in a 2-year rotation with soybeans did not result in sufficient increase in yields over continuous potatoes to justify this rotation.

Average specific gravity of the potatoes decreased when fertilizer applications were increased. There was no consistent increase or decrease in specific gravity when nitrogen in the fertilizer was increased from 130 to 190 pounds per acre. Increases in phosphate have tended to increase specific gravity of the potatoes, whereas increases in potash had the opposite effect.

Potatoes grown in rotation with redtop were consistently higher in specific gravity than those grown continuously. No difference in specific gravity resulted from growing potatoes in rotation with soybeans when compared with continuous culture.

For conditions similar to those under which this experiment was conducted, an application of 1,500 to 1,800 pounds per acre of an 8-12-12 or similar fertilizer is suggested.

Literature Cited

1. Murphy, H. J. and M. J. Goven. 1959. Nitrogen, spuds and specific gravity. Maine Farm Res. 7: 21-24.
2. Murphy, H. J. and M. J. Goven. 1959. Potash and processing potatoes. Maine Farm Res. 7: 3-8.
3. Murphy, H. J. and M. J. Goven. 1959. Factors affecting the specific gravity of the white potato in Maine. Maine Agr. Expt. Sta. Bull. 583.
4. Odland, T. E. and J. E. Sheehan. 1956. The response of Irish potatoes to different amounts and ratios of nitrogen, phosphoric acid and potash when grown in continuous culture. Am. Potato J. 33: 22-27.
5. Odland, T. E. and J. E. Sheehan. 1957. The effect of redtop and red clover on yields of following crops of potatoes. Am. Potato J. 34: 282-284.
6. Odland, T. E. and J. E. Sheehan. 1957. A comparison of sod crops for use in rotation with potatoes. Am. Potato J. 34: 312-314.
7. Sheehan, J. E. and T. E. Odland. 1956. A quarter century of potato variety trials in Rhode Island. Am. Potato J. 33: 161-165.

SOME EFFECTS OF SULFUR-MAGNESIUM RATIOS ON THE POTATO PLANT (*SOLANUM TUBEROSUM*)[1]

G. O. ESTES AND H. W. GAUSMAN[2]

The objective of this study was to determine some effects of factorially combined levels of sulfur and magnesium on the growth, quality, and chemical composition of the white potato.

The addition of these elements, particularly magnesium, to potato soils is well recognized as essential for best potato yields in areas where soils contain relatively low amounts of this element. High levels of magnesium have been shown to stimulate tuber formation (6, 10), to enhance the synthesis and translocation of sugars in potato plants (7, 10), and to retard protein synthesis (8). Starch content of the tubers (9), various aspects of phosphorus nutrition (4) and protein synthesis in potato plants (9) are believed to be related to the sulfur nutrition of potatoes.

MATERIALS AND METHODS

In carrying out these studies, three crops of Katahdin potatoes were grown in the greenhouse during 1958 and 1959. The experimental design was a randomized complete block with five replications. Treatments were factorially combined levels of S and Mg each at 0, 10, 20, and 30 pounds per acre. The sources of sulfur and magnesium were H_2SO_4 and MgO, respectively. The substratum was a virgin Caribou soil which was contained in 2-gallon crocks. The levels of total sulfur and total magnesium in the soil were 696 and 335 pounds per acre, respectively. Additions of N, P_2O_5, and K_2O were made before planting each crop at rates of 120, 240, and 240 pound per acre, repectively. The sources of these three nutrients were NH_4NO_3, KNO_3 and KH_2PO_4 from reagent grade chemicals. $Ca(OH)_2$ was added at 2,000 and 1,000 ppm. for the first and second crops, respectively. Calcium was not added for growing the third crop. The pH for all treatments and all crops varied within a range of 5.5 to 5.9. Minor elements were added according to Hoagland and Arnon (5). Bouyoucos moisture blocks were used to maintain soil moisture at approximately 30% on a dry weight basis. Supplemental light was provided to simulate a 14-hour day. The length of growing season of the three successive crops was 112, 115, and 120 days.

Soil and plant samples were prepared for K, Mg, and Ca determinations according to methods of AOAC (1). Determinations of Mg were made using the Beckman flame photometer. Potassium and Ca determinations were made using the Perkins-Elmer flame photometer. Samples were prepared for both SO_4 and PO_4 analyses by wet ashing two grams of plant tissue by the magnesium nitrate ignition method. Sulfate was determined with barium chloranilate (2). Chloride was determined according

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to the method of the U. S. Salinity Laboratory (12). Nitrogen analyses were made by the Kjeldahl method (1).

Radioactive sulfur, S^{35}, was used to study the effects of Mg and S treatments on the uptake and distribution of the radioisotope. An aqueous solution containing 150 uc of S^{35} was applied to the soil of each crock within one replication at the time of bossoming. Comparable samples were removed from each plant and dried between blotters at 60-65° C. Autoradiographs were prepared on Kodak, type-K, Industrial X-ray film using an exposure of 72 hours (3). The activity of the S^{35} was also determined in the dried plant material with a Geiger-Mueller counter.

Statistical analyses were made according to methods given by Snedecor (11).

Results and Discussion

The following results represent data from three crops with the exception of the data from chemical analyses. The analyses represent data from two crops.

Plant height: In crop one, the response of plant height to additions of S resulted in a significant deviation from linear regression regardless of the Mg treatments. In contrast, crops two and three showed a linear response to S where Mg was added with the exception of the additions of 30 pounds of Mg per acre in crop three. However, there was a significant deviation from linear regression for all crops when Mg was added with the exception of the 20 pound level of Mg in crop two.

The data for the effect of treatments on plant height for the three crops are presented in Table 1. Additions of Mg and S did increase plant height when compared with the 0:0 treatment of the first crop. During the second crop, the 20:10, 30:20, and 30:30 ratios of S to Mg significantly increased plant height compared with the 0:0 treatment. The 30-pound level of S applied in the absence of Mg produced a significant reduction in plant height compared with the standard. The 10 and 20 pound levels of S did not significantly affect plant height.

Additions of Mg increased plant height over the 0:0 treatment at the 0, 10, and 20 pound S levels during the third crop. Additions of S alone in excess of 20 pounds per acre did not significantly increase the height of plants in the third crop.

Dry weights: An analysis of variance for each crop indicated that the dry weights of the potato plants of the first two crops were significantly affected by treatments. An analysis of variance on the combined dry weights of the three crops, however, showed no significant treatment effects, nor was the crop treatment interaction significant. The interaction of Mg with S was significant during both the first and second crops, while the effect of Mg was significant only during the first crop. Furthermore, a significant deviation from linear regression of dry weights on S occurred at the 0 and 30 pound level of Mg during the first crop. During the second crop, dry weights responded linearly to S only at the 10 pound Mg level. Quadratic and cubic responses were present at the 30 pound Mg level.

The average dry weights of the total plant for each of the three crops are given in Table 2.

TABLE 1.—*Effects of sulfur and magnesium treatments on plant height for three crops. (Data are given as an increase (+) or as a decrease (—) of treatments compared with appropriate crop standards, average of five replications for each crop.)*

Treatment S:Mg	Crop 1	Crop 2	Crop 3	Total
	Height of plants			
Lbs. per acre	Inches	Inches	Inches	Inches
0:0 (standard)	26.58	21.43	21.50	
0:10	—0.44	—1.92**	+0.55	—1.81
0:20	—1.35*	—1.20	+0.55	—1.88
0:30	—2.97*	—2.17**	+1.36*	—3.78
10:0	—1.93**	0.00	+0.75*	—1.18
10:10	—0.91	—2.48	+1.19**	—2.20
10:20	—1.22*	+0.02	+1.77**	+0.57
10:30	—0.69	—2.49**	+1.17**	—2.01
20:0	—0.87	+0.12	+0.70*	—0.05
20:10	—3.29**	+1.57**	+0.55	—1.17
20:20	—3.04**	+0.84	+0.64*	—1.56
20:30	—1.39**	—3.68**	+2.12**	—2.95
30:0	—0.64	—1.09*	+0.08	—1.65
30:10	—0.35	—1.05	—0.34	—1.74
30:20	—0.67	+2.20**	—0.31	+1.22
30:30	—2.38*	+2.18**	+0.49	+0.29

*P = 0.05
**P = 0.01

TABLE 2.—*Dry weights of the total plant as an average of five replications for each of three crops.*

Treatment S:Mg	Mean Crop 1	Mean Crop 2	Mean Crop 3	Mean
Lbs. per acre	Gms.	Gms.	Gms.	Gms.
0:0	16.85	8.64	19.37	14.95
0:10	14.76	6.12	21.82	14.23
0:20	13.38	8.11	20.78	14.09
0:30	11.41	8.72	20.56	13.56
10:0	13.09	8.03	19.43	13.51
10:10	15.31	7.45	20.46	14.40
10:20	13.61	8.55	22.43	14.86
10:30	15.92	7.85	19.12	14.29
20:0	14.33	8.21	17.61	13.38
20:10	13.34	9.41	20.24	14.33
20:20	12.64	8.60	21.15	14.13
20:30	13.64	5.86	23.02	14.17
30:0	15.81	8.12	20.08	14.67
30:10	14.04	8.00	20.09	14.04
30:20	14.97	8.78	17.64	13.79
30:30	12.05	10.06	19.82	13.97
Mean	14.07	8.16	20.23	

L.S.D.'s	Treatment x Crops	Crops
P = 0.05	3.28	0.82
P = 0.01	4.31	1.08

Number of tubers: The number of tubers per plant was significantly affected by both Mg and S additions to the soil, Table 3. Magnesium additions of 20 and 30 pounds per acre and S additions of 10 and 20 pounds per acre produced the greatest number of tubers. For example, 20 pounds of S with 20 pounds of Mg produced an average of 9.9 tubers per plant as compared with 6.2 tubers per plant when neither S nor Mg was added.

Chemical composition: Table 4 shows the N and PO_4 content of the total plant (tops, roots, and tubers) as an average of the first two crops. The S x Mg interaction had a significant effect on the N level. The greatest N content of 2464 milliequivalents per liter was obtained at the 20 pound rate of Mg in the absence of S. Further, a partitioning of variance into regression components indicated that significant linear and quadratic effects of treatments on N content were present due to S at the 20 and 30 pound Mg levels, respectively.

The interaction of S with Mg also affected the PO_4 content, Table 4. This was a result of a quadratic response in PO_4 content of plants to S at the 20 and 30 pound rate of Mg. The highest PO_4 content of 209 milliequivalents per liter occurred with the treatments having 20 pounds of S with 30 pounds of Mg.

Treatments had no significant effect on the sulfate content of the plants.

Correlations on chemical composition: Table 5 presents the significant correlation coefficients found among the chemical components of the plant tops for the first two crops. Significant and positive correlation coefficients were found between: (a) N and Mg, $r = 0.4075$; (b) K and Mg, $r = 0.5026$; and (c) N and K, $r = 0.6200$. Significant and negative correlations coefficients were obtained between: (a) PO_4 and Cl, $r = -0.3967$; and (b) Ca and K, $r = -0.3868$.

Table 6 presents the significant partial correlation coefficients between various chemical components of the plant tops of the first and second crops. Positive partial correlation coefficients were obtained between: (a) Mg and N with Cl constant, $r = 0.4275$; (b) Mg and N with PO_4 constant, $r = 0.4149$; (c) Mg and K with Ca constant, $r = 0.5216$; and (d) N and K with Mg constant, $r = 0.5259$. Negative partial correlations were found between: (a) Cl and PO_4 with Mg constant, $r = 0.3982$; and (b) K and Ca with Mg constant, $r = -0.4216$.

Calcium levels in the plant tops were low in relation to high levels of Mg and K (data not shown). Potassium and Ca levels were significantly correlated while there was no evident association between Mg and K. Although there was a positive simple correlation between Mg and N, a partial correlation of Mg with K constant was not significant. Hence, K rather than Mg provided the significant influence on N levels. Magnesium and K were significantly and positively correlated , however, indicating that Mg may have a beneficial influence on K levels in the tops of the potato plants. A significant, negative relationship between Cl and PO_4 was also obtained.

Radioisotope studies: Autoradiographs of leaflets from plants treated with radioactive S^{35} which received the O:O and O:30 S:Mg treatments

TABLE 3.—*Effects of sulfur and magnesium treatments on number of tubers per plant as an average of three crops each with five replications.*

Mg. lbs. per acre	Sulfur, pounds per acre				
	0	10	20	30	Mean
	Number tubers per plant				
0	6.2	8.7	7.3	6.2	7.10
10	6.5	6.9	7.0	6.9	6.82
20	7.9	7.5	9.9	7.3	8.15
30	7.3	7.6	6.5	7.3	7.18
Mean	7.0	7.7	7.7	6.9	7.31

L.S.D.'s	Mg	S	Mg x S
P = 0.05	0.56	0.56	1.11
P = 0.01	0.73	0.73	1.47

TABLE 4.—*Nitrogen and phosphate contents of the total plant in milliequivalents per liter as an average of two crops, each with five replications.*

Mg. lbs. per acre	Sulfur, pounds per acre									
	0		10		20		30		Mean	
	N	PO_4	N	PO_4	N	PO_4	N	PO_4	N	PO_4
0	2120	194	2289	199	2200	195	2220	193	2207	195
10	2327	188	2260	201	2279	189	2293	188	2290	191
20	2464	191	2290	187	2264	175	2212	199	2308	188
30	2355	185	2122	193	2302	209	2339	194	2280	195
Mean	2317	190	2240	195	2261	192	2266	194	2271	192

L.S.D.'s P = 0.05 Mg x S for N = 162
Mg x S for P = 16

*Milliequivalents per liter x equivalent weight equals ppm.

TABLE 5.—*Correlation coefficients on chemical components of the plant tops.*

Variable	Correlation coefficient
N x Mg	0.4075*
K x Mg	0.5026**
Cl x PO_4	—0.3967*
Ca x K	—0.3868*
N x K	0.6200**

*P = 0.05
**P = 0.01

TABLE 6.—*Partial correlation coefficients on chemical components of the plant tops.*

Variable	Constant	Correlation coefficient
Mg x N	Cl	0.4275*
Mg x N	PO_4	0.4149*
Cl x PO_4	Mg	—0.3982*
N x K	Mg	0.5259**
Mg x K	Ca	0.5216**
K x Ca	Mg	—0.4216*

*P = 0.05
**P = 0.01

are given in Figs. 1 and 2. The greatest concentration of radioactive S^{35} is indicated by the dark regions of the leaflet. As shown, the S^{35} distribution in the leaflets of plants which received the 0:0 treatment, was relatively uniform, while leaflets of plants which received the 0:30 ratio of S to Mg had the radioisotope concentrated near the margins of the leaves. This was characteristic of all treatments which had a low S to high Mg ratio. An increase in the amount of applied S, however, tended to reduce the amount of radioactive S^{35} in the leaf tissue of the plants. The significance of this is not known.

FIG. 1—Autoradiograph of leaves of a potato plant treated with radioactive S^{35} which received 0 pounds of S and 0 pounds of Mg per acre, indicating a relatively uniform distribution of S^{35} through the tissue.

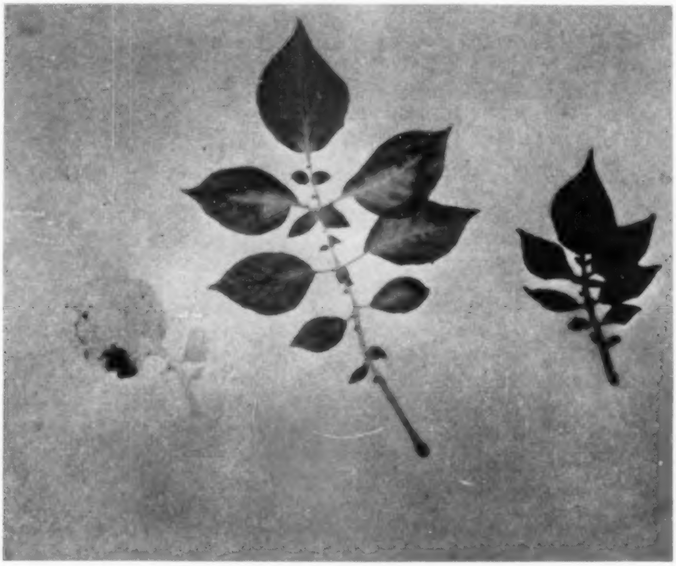

FIG. 2.—Autoradiograph of leaves of a potato plant treated with radioactive S^{35} which received 0 pounds of S and an equivalent of 30 pounds of Mg per acre, indicating a non-uniform distribution of S^{35} (center leaflet) in the tissue.

SUMMARY AND CONCLUSIONS

Greenhouse studies were conducted during 1958 and 1959 to determine the effect of various ratios of S to Mg on the growth and nutrient composition of Katahdin potato plants. Results from three crops indicated the following:

1. Additions of Mg and S did not increase plant height during the first crop. During the second and third crops, several S:Mg ratios such as 20:10, 30:20, and 30:30 significantly increased plant height.
2. Treatments significantly increased the dry weight only of the second crop. This increase in total dry weight of the plants was obtained with the 20:10 and 30:30 ratios of S to Mg.
3. Numbers of tubers per plant were significantly increased by either Mg or S and by the interaction of S with Mg. Considering the main effects of Mg and S, the greatest number of tubers was obtained with the 20 pound level of Mg, and the 10 and 20 pound level of S.
4. Magnesium additions significantly increased the nitrogen content of the plants. The interaction of S with Mg significantly reduced the PO_4 level of the plants.
5. Uptake by leaflets of potato plants from soil application of S^{35} was influenced by S to Mg treatments. A uniform distribution of S^{35} occurred in leaflets of plants receiving an even ratio of S to Mg. A ratio of S to Mg such as 0:30 resulted in an uneven distribution of S^{35} in the leaflets.

6. Several of the nutrient components of the plant tops were significantly correlated. In this respect, positive correlations occurred between Mg and N, K and N, and Mg and K. Negative correlations occurred between Cl and PO_4, and K and Ca.

Literature Cited

1. Association of Official Agricultural Chemists. 1950. Official and tentative methods of analysis. Washington. D. C., Ed. 7.
2. Bertolacini, R. J., and J. E. Barney. III. 1957. Colorimetric determinations of sulfate with barium chloranilate. Anal. Chem. 29: 281-283.
3. Gausman, H. W., and A. B. Awan. 1956. Effects of chloride from $CaCl_2$ on P^{32} accumulation in potatoes. Agron. J. 48: 431.
4. Gausman, H. W., C. E. Cunningham, and R. A. Struchtemeyer. 1958. Effects of chloride and sulfate on P^{32} uptake by potatoes. Agron. J. 50: 90-91.
5. Hoagland, D. R., and D. I. Arnon. 1950. The water culture method for growing plants without soil. Calif. Agric. Exp. Sta. Cir. 347.
6. Krackenberger, H. F., and W. J. Petersen. 1954. Effects of environment on the magnesium content of plants. Southern Co-op. Service Bull. 36: 98-118. (Soils and Fert. 18: 1263. 1955).
7. Lewin, G. and S. Lewin (Translators). 1956. Magnesium — a plant food. Bergbau-Handel. Berlin, Germany.
8. Mulder. E. G. 1956. Nitrogen-magnesium relationships in crop plants. Plant and Soil. 7: 341-376.
9. Pirson, A. 1955. Functional aspects in mineral nutrition of green plants. Ann. Rev. Plant Physiol. 6: 71-114.
10. Shugar, Y. A. 1956. Effect of magnesium on the distribution of sugars in plants. Fixiol. Rast. 3: 32-35. (B.A. 32: 35188. 1958).
11. Snedecor, G. W. 1956. Statistical methods. Iowa State College Press, Ames, Iowa. Ed. 5.
12. U. S. Salinity Laboratory. 1954. Diagnosis and improvement of saline and alkali soils. U.S.D.A. Agr. Handbook 60: 129.

15TH ANNUAL CONFERENCE ON HANDLING PERISHABLE AGRICULTURAL COMMODITIES

The 15th National Conference on Handling Perishable Agricultural Commodities will be held at Purdue University, Lafayette, Indiana, March 20 through March 23, 1961. The objectives of the conference are to bring together those persons interested in striking directly at preventable losses and damages in the transportation of perishable fruits and vegetables.

This conference is sponsored by Purdue University, the Association of American Railroads, and the American Railway Development Association with the cooperation of Railway Inspection Agencies and the United States Department of Agriculture.

Programs for this conference may be obtained by writing the Horticulture Department, Purdue University, Lafayette, Indiana.

EFFECT OF SPECIFIC GRAVITY, STORAGE, AND CONDITIONING ON POTATO CHIP COLOR[1]

SHIRLEY LYMAN AND ANDREA MACKEY[2]

The importance of potato chips in the commercial use of potatoes is cited by Hedlund (8) who points out that potato chips account for the largest per cent of the processed portion of the crop. Nine and one-half per cent of the 1957 potato crop that was consumed as food was in the form of chips and shoestring potatoes. Commercial frying is being used not only for these products but also for French-fried potatoes, frozen patties and other products.

According to a survey by Du Pont and Company (5), "store decision" accounted for 80.6% of potato chip sales. Apparently, consumers want potato chips, and are willing and able to pay for them. The factors that contribute to the consumer's impulse buying of potato chips are unknown, but good appearance doubtless contributes to initial acceptance while overall quality and intended use are important in repeat sales.

Among the factors that contribute to potato chip quality, color is one of the most important. A light color when fried is the primary requirement (16). The dark color of potato chips made from tubers which have been stored at low temperatures has long been recognized as a problem of the chipping industry. Yet, since production of chips is a year-around industry, low storage temperatures are frequently used to inhibit sprouting and spoilage of raw stock.

For chipping, the Potato Chip Institute International recommends several varieties of potatoes that normally mature with a low reducing sugar content. Among these is the Russet Burbank variety (1). The effects of certain procedures on the color of chips made from potatoes of this variety were the subject of the study herein reported.

Many interesting reports have appeared in the literature, dealing with the effect of potato variety, storage temperature, sugar content and amino acid effects, as well as other factors, on the color of potato chips. It is difficult to give full credit to all those who have worked in this field, due to limitation of space. Probably the nearest approach to a complete list of references is that of Talburt and Smith in the book, "Potato Processing" (19).

Excessive browning usually occurs when chips are processed from potatoes taken directly from cold storage, or from potatoes which have been out of cold storage for only a short time. As mentioned above, the amount of reducing sugar in the tuber is believed to be closely associated with the degree of browning during frying (1,3,4,10). Others (15) believe that potato chip color is correlated with both reducing sugars and sucrose. Habib and Brown (6) state that the magnitude of the reducing sugar vs. color correlation, –0.85, adds more evidence to their importance in color formation. They also point out that the correlation coefficient of free amino nitrogen vs. color, –0.72, was also of considerable importance. They recommend that both factors be considered when evaluating a potato

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variety for chipping quality. Later Habib and Brown (7) found evidence that light color of chips was associated with a low content of basic amino acids and reducing sugars. They point out that amino acids as well as sugars differ by variety and by the conditions under which potatoes are stored. Cold storage at 40° F. resulted in slight changes in amino acids, but reconditioning at 75° F. resulted in disappearance of various amino acids, especially the basic amino acids, lysine, histidine, and arginine.

Translocation in nitrogen fractions occurs during storage (20). During the first 60 days of storage at room temperature, the so-called "rest period", little change occurred in various nitrogen fractions of Irish Cobbler potatoes. In the next 40 days, the "rest-end" stage, soluble nitrogen, especially amide nitrogen increased in the terminal bud and cortex with a corresponding decrease in the protein of the pith. During the next 30 days, the "sprouting" stage, protein nitrogen increased in the vicinity of the terminal bud, while in other parts of the tuber it decreased. Decreases of amino nitrogen in the pith and in the cortex of the tuber were also ascertained.

In the model system that they used, consisting of filter paper dipped in solutions of various ingredients, Smith and Treadway (17) found that sugar alone or protein alone did not cause browning. A combination of potato-protein fraction plus reducing sugar plus glycine, or a combination of glucose and glycine or fructose and glycine resulted in a dark color during frying.

Talburt and Smith (19) call attention to several non-sugar components of potatoes which could conceivably react as reducing sugars. These include tyrosine, ascorbic acid, cysteine, glutathione, and inositol. Ascorbic acid decreases when potatoes are stored at 50-59° F. At lower temperatures, loss of ascorbic acid is even greater.

The maturity and specific gravity of the tubers appear to be related factors which influence the color of potato chips. It has been reported that immature tubers produce darker colored chips than do mature tubers (18). Immature tubers tend to have lower specific gravity than do mature tubers.

Kunkel, et al (11) report a study of chipping quality of Russet Rural potatoes that had been conditioned for five weeks. The storage period preceding conditioning was not stated. Twenty thousand pounds were separated into two specific gravity groups, one with a mean of 1.0916 and one with a mean of 1.0777. Chips prepared from the low specific gravity group of this variety were generally darker in color even after prolonged conditioning. These chips absorbed slightly more fat and the percentage of saleable chips was slightly lower than for chips prepared from the high specific gravity group.

Conditioning, that is, holding tubers at room temperature for a short time after cold storage, reduces the content of sugar of certain varieties (6, 7). It has been reported (7) that the content of amino acids may be reduced as well. Consequently, light-colored chips may be processed from tubers of these varieties which have been stored at cold temperatures followed by conditioning at room temperatures.

Conditioning may usually be accomplished by holding at 70° F. for one to four weeks if potatoes are of the right variety and have not been stored at too cold a temperature for too long (22).

Denny and Thornton (4) showed that the rate of increase of reducing sugar was influenced by the starting date at a given temperature. When placed in cold storage, about two months after harvest, reducing sugar rose rapidly to a maximum value at the third removal stage (59 days) and then showed decreasing values at the fourth removal stage (93 days). When cold storage was started about four months after harvest (August to December), the rate of reducing sugar increase was retarded, but the maximum accumulation followed by a decline which was noted when potatoes were put in cold storage earlier, was not observed. Wright, et al. (22) state that potatoes stored at 50° F. can be processed into chips directly from storage. Variety appears to influence not only the capacity of the tubers to re-condition but also the length of conditioning time necessary before light-colored chips can be produced (6, 13, 21).

The Russet Burbank variety has several characteristics of value for potato chip processing. It can be stored for long periods of time, so that it is available when needed. A large proportion of the crop tends to have high specific gravity, often averaging 1.092 or higher, which would result in larger yields for the processor (9, 12). As mentioned above, this variety tends to mature with a low reducing sugar content.

This study was carried out to determine for the Russet Burbank variety, the influence on chip color of (a) specific gravity of tubers, (b) storage time at 40° F. and 50° F., and (c) conditioning for various lengths of time after storage of one to five months at 40° F.

Materials and Methods

Russet Burbank potatoes were obtained at harvest from 15 farms located in different areas of Oregon. Tubers from each farm were divided into low and high specific gravity classes, 1.080 and 1.100, using the salt brine method of Clark, Lombard and Whiteman (2). They were placed in storage at 40° F. or 50° F. at a relative humidity of 82 to 84 per cent.

Samples were removed from 40° F. storage after one, two, three, four and five months. At each interval, some of the tubers were used for preparation of chips directly after removing them from cold storage. Those remaining were held at room temperature, approximately 75° F. Representative tubers were tested after one, two, three and four weeks of conditioning.

Samples were removed from 50° F. storage after one, two and three months, and all were used for preparation of chips directly from storage.

In order to secure scores for chip color that would be representative of each specific gravity group and each storage period or conditioning time, tubers from each farm were included in all the tests.

Preliminary trials were carried out to determine the number and location of chips needed from a tuber that would be representative of its color performance. These trials indicated that differences between tubers were greater than differences within a tuber. One chip from the center of a tuber was judged to be characteristic.

Therefore, one chip, one-sixteenth to one-twentieth inch in thickness, from the center of each tuber, was cut and fried for evaluation of color. Five chips were fried together in two quarts of cottonseed oil at an initial temperature of 347° F. The chips were removed from the fryer when the oil ceased to bubble. The potato chips were drained and judged.

This procedure was similar to that followed by Denny and Thornton (3) except that they used two slices from the middle portion of the tuber rather than one.

A color score was given each potato chip by comparing with a color reference standard, National Potato Chip Institute form number 1206-U. On this standard a scale of one to ten is used, with "*one*" representing very light-colored chips and a high score, in contrast with "*ten*" which represents extremely dark color and a low score. Two judges evaluated each chip for darkness versus lightness and uniformity of color. The scores given by these two judges for chips from tubers representing each of the fifteen farms were averaged for presentation in table form.

The significance of specific gravity, storage time and conditioning time in affecting chip color was determined by means of analysis of variance and least significant difference between means.

Results

Regardless of cold storage temperature and period, tubers fried directly from storage without conditioning usually produced chips that were sufficiently dark to be undesirable, although tubers stored at 50° F. produced lighter colored chips than did tubers stored for the same length of time at 40° F. According to Murphy and Goven (14), potato chip manufacturers desire chips having a color score within the range of four to six rated on the scale mentioned above. Miyamoto, Wheeler and Dexter (13) recommend a color score of three on this scale. The color of the chips improved, that is, became lighter, as the tubers were held at room temperature for increasing periods of time, Table 1.

Specific gravity influenced potato chip color. Tubers of high specific gravity consistently produced chips of lighter color than did tubers of low specific gravity, Fig. 1. They were not as dark after equivalent periods

TABLE 1.—*Effect of specific gravity, temperature and time of storage, and conditioning period on the color of potato chips processed from Russet Burbank potatoes.*[1]

Storage time and temperature	Specific Gravity									
	1.080					1.100				
	Conditioning period, weeks at 75°F.					Conditioning period, weeks at 75°F.				
	0	1	2	3	4	0	1	2	3	4
1 month at 40°F.	8.08[2]	7.25	6.85	5.28	5.83	7.23	7.43	5.93	5.00	4.00
2 months at 40°F.	8.43	6.80	5.87	4.33	4.20	7.53	5.40	4.20	3.90	2.86
3 months at 40°F.	7.90	6.03	5.70	3.69	4.17	7.60	5.17	4.00	3.73	2.47
4 months at 40°F.	7.97	4.97	4.50	4.03	2.95	6.00	4.80	3.67	3.27	2.17
5 months at 40°F.	6.93	5.11	4.64	3.42	3.37	6.57	4.37	2.63	2.27	1.93
1 month at 50°F.	7.70	..	..	..	..	6.50	..	..	..	..
2 months at 50°F.	7.27	..	..	..	..	6.27	..	..	..	..
3 months at 50°F.	6.71	..	..	..	..	4.87	..	..	..	..

[1]Analysis of variance demonstrated that color of chips was significantly affected by specific gravity, length of cold storage and conditioning time.

[2]Each number represents the average of 30 scores, tubers from 15 farms and two judges. Color score based on National Potato Chip Institute color standard in which 1 represents a very light-colored chip, a desirable score; and 10 represents a very dark color, an undesirable score.

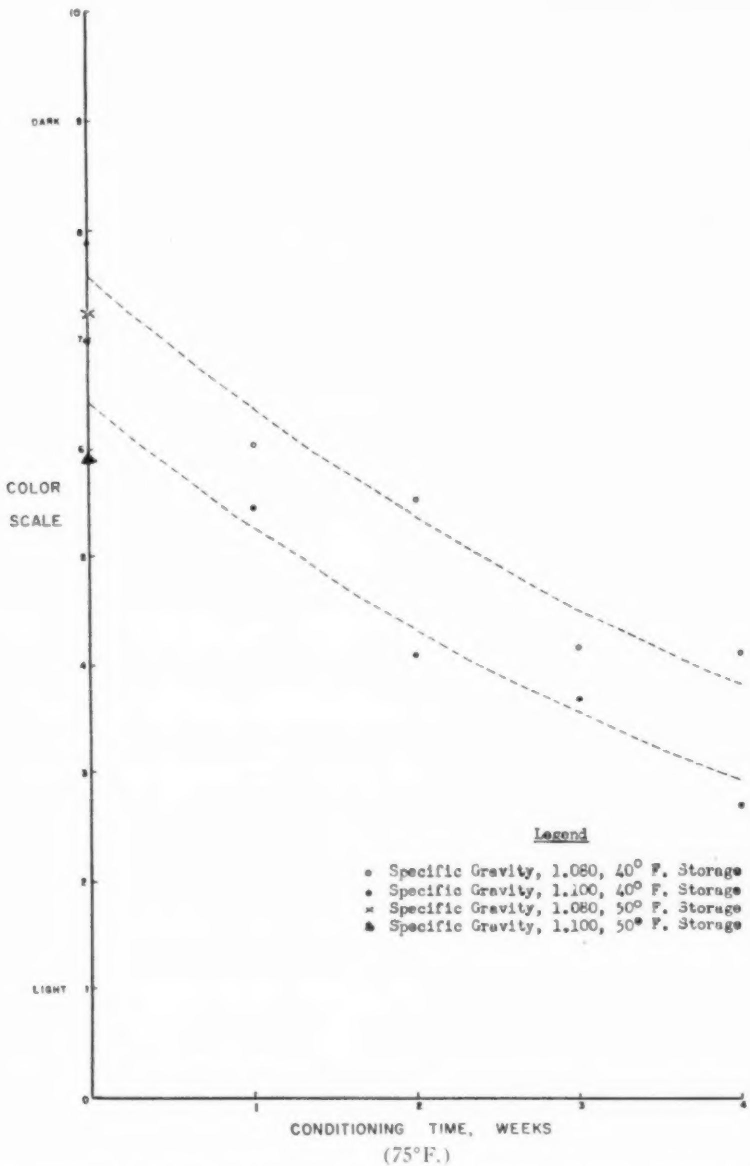

FIG. 1.—Effect of specific gravity and conditioning on potato chip color. Average score for potatoes stored one to five months.

in cold storage, and when held at room temperature after cold storage tubers of high specific gravity conditioned to give light-colored chips more rapidly than did low-specific-gravity tubers. In most cases, one week of conditioning at room temperature, 75° F., produced chips of satisfactory color, that is, scoring five to six, when potatoes of 1.100 specific gravity were fried, Table 1. In all cases, two weeks of conditioning produced chips of satisfactory color when tubers of this specific gravity were used. When tubers of 1.080 specific gravity were fried, two weeks of conditioning were usually necessary and in some cases three weeks of conditioning were necessary. Chips of suitably light color, scoring two to six, were produced from all tubers after three or four weeks of conditioning at room temperature. In contrast to the conditioning period necessary for some varieties, this is relatively short. For example, potato chips from Russet Rural tubers had a color score of three after seven weeks of conditioning at 70° F. (13). Thiessen (21) found that Bliss Triumph tubers could not be conditioned to produce chips of a satisfactory color during the winter months.

As the period in cold storage increased, the time needed for conditioning to produce chips of a light, desirable color was less. For example, the color score for chips made from tubers of low specific gravity, 1.080, after one month of storage at 40° F. followed by one week of conditioning, was 7.25; whereas, after five months of storage at 40° F. followed by one week of conditioning, the score was 5.11. The need for shorter conditioning periods after increasing length of time in cold storage was noted for both specific gravity groups, Table 1. After three, four and five months of storage at 40° F. only one week of conditioning was required for the production of chips in the color range of four to six for both specific gravity groups.

Summary and Conclusions

Russet Burbank potatoes of two specific gravity classes were placed in 40° F. and 50° F. storage. Samples were removed from storage at monthly intervals up to five months. Chips were fried directly from storage and after conditioning at 75° F. from one to four weeks. Two judges scored each potato chip for color using a reference, N.P.C.I. number 1206-U.

By means of the analysis of variance, specific gravity, storage time and conditioning time were each found to have significant effects on color.

Regardless of storage temperature, tubers fried directly from storage at 40° or 50° F. without conditioning usually produced chips that were dark and undesirable. The color of the chips improved, became lighter, as the conditioning period increased. As the length of the storage period increased, the length of the conditioning period necessary to produce chips of desirable color decreased.

Specific gravity influenced potato chip color. Tubers of high specific gravity, 1.100, produced lighter colored chips than did the tubers of low specific gravity, 1.080.

Early in the season after one or two months of cold storage, chips of the desired color were produced from high-specific-gravity tubers after two or three weeks of conditioning and from low-specific-gravity

tubers after three or four weeks of conditioning. Later in the season after three to five months of cold storage, light-colored chips were produced from both specific gravity groups after one week of conditioning.

Literature Cited

1. Brown, H. D. 1959. The role of tuber selection in a quality control program for potato chippers. Proc. Tenth Annual Potato Utilization Conf., p. 34-36.
2. Clark, C. F., P. M. Lombard, and Elizabeth Fuller Whiteman. 1940. Cooking quality of the potato as measured by specific gravity. Am. Potato J. 17: 38-45.
3. Denny, F. E., and Norwood C. Thornton. 1940. Factors for color in the production of potato chips. Boyce Thompson Institute for Plant Research, Contributions 11: 291-303.
4. Denny, F. E., and Norwood C. Thornton. 1942. Potato varieties: Sugar forming characteristics of tubers in cold storage and suitability for production of potato chips. Boyce Thompson Institute for Plant Research 12:217-252.
5. DuPont De Nemours, E. I., and Company Incorp. 1954. Latest facts about potato chip, pretzel, and snack purchases in super markets. Wilmington 98, Delaware.
6. Habib, Ahmed T., and H. D. Brown. 1956. Factors influencing the color of potato chips. Food Tech. 10: 332-336.
7. Habib, Ahmed T., and H. D. Brown. 1957. Role of reducing sugars and amino acids in the browning of potato chips. Food Tech. 11: 85-89.
8. Hedlund, Floyd F. 1959. Influence of processing on fresh market utilization of potatoes. Proc. Tenth Annual Potato Utilization Conf. p. 21-23.
9. Heinze, Peter H., Mary E. Kirkpatrick, and Elsie F. Dochterman. 1955. Cooking quality and compositional factors of potatoes of different varieties from several commercial locations. U.S.D.A. Tech. Bull. No. 1106.
10. Kirkpatrick, Mary E., Peter H. Heinze, Charles C. Craft, Beatrice M. Mountjoy, and Claire E. Falatko. 1956. French-frying quality of potatoes as influenced by cooking methods, storage conditions, and specific gravity of tubers. U.S.D.A. Tech. Bull. No. 1142.
11. Kunkel, R., P. F. Gifford, A. D. Edgar, and A. M. Binkley. 1952. The mechanical separation of potatoes into specific gravity groups. Colorado Agr. and Mechanical College Bull. 422-A.
12. Mackey, Andrea, Sue Joiner, Ida Cecil, and Joy Stockman. 1958. Survey of specific gravity of russet burbank potatoes grown in central Oregon and the Klamath Basin, 1957 crop. Am. Potato J. 35: 739-741.
13. Miyamoto, T., E. J. Wheeler, and S. T. Dexter. 1958. Ventilation of chipping potatoes during the conditioning period. Am. Potato J. 35: 778-783.
14. Murphy, H. J., and M. J. Goven. 1959. Nitrogen, spuds and specific gravity. Maine Farm Research 7 (1):21-24.
15. Shallenberger, R. S., Ora Smith, and R. H. Treadway. 1959. Role of the sugars in the browning reaction in potato chips. J. Agri. and Food Chem. 7: 274-277.
16. Smith, Ora. 1955. How to grow and store potatoes for the chip industry. Am. Potato J. 32: 265-271.
17. Smith, Ora, and R. H. Treadway. 1960. Function of the protein and other nitrogenous fractions of potatoes in chip color development. Am. Potato J. 37: 139-143.
18. Sweetman, Marion Deyoe. 1930. Color of potato chips as influenced by storage temperatures of the tubers and other factors. J. of Agr. Research 41: 479-490.
19. Talburt, W. F., and Ora Smith. 1959. Potato Processing. The Avi Publishing Company, Westport, Conn.
20. Tagawa, T., and Y. Okazawa. 1955. Physiological and morphological studies on potato plants. Part 9. Studies on nitrogen metabolism in potato tubers during the storage period. J. Fac. Agr. Hokkaido Univ. Sapporo, 50: 65-73.
21. Thiessen, Emma J. 1947. The culinary qualities and nutritive values of potatoes grown upon dry and irrigated land. Wyoming Agr. Expt. Sta. Bull. 280.
22. Wright, R. C., Martha E. Davis, and Carl E. Hendel. 1950. Crops in peace and war. U.S.D.A. Yearbook of Agriculture 1950-1951. Washington, D.C. p. 188-189.

THE EFFECT OF GAMMA IRRADIATION ON THE INCIDENCE OF BLACK SPOT, AND ASCORBIC ACID, GLUTATHIONE AND TYROSINASE CONTENT OF POTATO TUBERS[1]

D. J. COTTER AND R. L. SAWYER[2]

Numerous reports prior to the initiation of this work indicated that sprouting of potatoes can be controlled by the use of irradiation (3, 12, 15). Evidence accumulated also suggested adverse effects on tuber quality. Sawyer, Dallyn and Cotter (11) noted that after-cooking-blackening, a non-enzymatic darkening of the cooked tuber, increased corresponding to the irradiation dosage applied. Waggoner (19) showed that the number of cells forming the wound periderm was reduced one-half by dosages of 20,000 roentgens. He pointed out the possibility of increased rot occurring "under certain conditions of inoculum, wounding and atmosphere."

As a result of this interest in tuber irradiation and the uncertainty of the influence of irradiation on quality factors, studies concerning the effect of gamma irradiation on black spot of potatoes were initiated. Black spot, a physiological disorder described by Scudder (13), is characterized by varying amounts of subsurface black discoloration which lowers tuber quality and in many cases renders them unmarketable. These spots are located in the tissue commonly known as the cortex region of the tuber.

Preliminary results indicated that irradiation increased the black spot, and subsequent experiments were conducted during the next two years to confirm these results and to study the mechanism causing this irradiation-induced increase in black spot.

MATERIALS AND METHODS

All tubers in this study were irradiated in the fall at the Brookhaven National Laboratory using gamma rays from Cobalt^{60} in the gamma field described by Sparrow and Singleton (16). Dosages expressed as roentgens (r), were calculated on the basis of ionizations in air. The desired dosage was obtained by varying the distance from the gamma source to the tubers.

The samples for black spot study consisted of 18 pounds of medium sized tubers which were stored at 40° F. until they were evaluated in early February. Bruising, necessary to initate the production of the black pigment (1), was done 4 days prior to evaluation. Tubers were peeled abrasively and then hand trimmed to bring out the maximum black spot. In the laboratory analysis comparable samples were used without bruising.

The severity of black spot was determined by an index devised by Scudder (13). The full range of the index is 0 to 90. Index values of 10 or less are not considered important commercially.

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All treatments were set-up factorially and statistical analysis was by the analysis of variance (17), and Duncan's multiple range test (5). The variance was frequently proportional to the magnitude of the mean and these data were transformed by the formula $\sqrt{x + 0.5}$ where x is the observed value (17).

Ascorbic acid was determined by the xylene method of Nelson and Summers (8). A sample of approximately 100 grams from 5 unbruised tubers was blended with 500 ml of 3% meta-phosphoric acid. Dry weight was determined and a correction made for the dilution caused by tissue moisture.

Sulfhydryl compounds, such as glutathione and cysteine, were estimated by an ascorbic acid method modification proposed by Owen, Iggo and Horn (9). They showed that p-chloromercuribenzoic acid was a sulfhydryl poison while not affecting the reducing property of ascorbic acid. Preliminary results with this compound demontrated this to be true. Sulfhydryl content was estimated by subtracting the poisoned from the non-poisoned samples and converting the difference to equivalent glutathione.

Tyrosinase activity determinations were conducted manometrically by the method of Goddard and Holden (6). Tissue in the cortex region of the stem end from ten tubers constituted a treatment sample. Preliminary results showed this region to be highest in enzyme activity. All tubers were peeled prior to sampling. Final results were expressed as cubic centimeters of oxygen per gram of dry or fresh weight per hour.

Results

The effect of gamma irradiation on black spot index, ascorbic acid and glutathione content is shown in Table 1.

Table 1.—*The effect of irradiation on the mean black spot index, ascorbic acid, and glutathione content (mg per 100 grams of fresh weight) of potato tubers.*

Dosage	Black spot index[1]	Ascorbic acid[1] (mg)	Glutathione (mg)
0	15	7.9	6.3[2]
10,000 r	13	7.2	6.6[2]
40,000 r	34	6.4	7.7[3]

[1]Differences significant at 99:1 odds.
[2]Not significantly different.
[3]Significantly different from [2] at 19.1 odds.

These data support previous results that irradiation does increase black spot. Although a dosage of 10,000 r was not sufficient to increase black spot, a highly significant variety x dosage interaction shown in Fig. 1 illustrates varietal responses to irradiation dosages .

A subsequent test brought out the fact that a minimum dosage necessary to initiate a significant increase in black spot can not be specified (Fig. 2). In this test, a highly significant increase in black spot occurred at a dosage of 5000 r. The results were similar for both Pontiac and Ontario varieties.

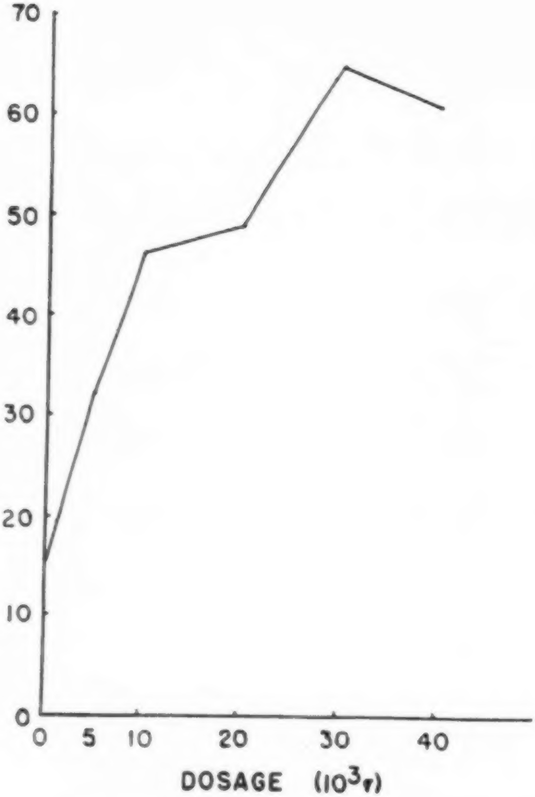

FIG. 1. The influence of gamma irradiation on black spot indexes of three varieties.

All irradiation dosages reduced the ascorbic acid content, and increased glutathione content significantly at 40,000 r.

The effect of planting date on black spot, ascorbic acid and glutathione contents is shown in Table 2.

TABLE 2.—*The influence of planting date on the mean black spot index, the ascorbic acid and glutathione content (mg per 100 grams of fresh tissue) of potato tubers.*

Planting date	Black spot index	Ascorbic acid (mg)	Glutathione (mg)
April 9	23	7.0	6.4
June 15	18	7.3	7.2
	*	*	NS

*Significantly different at 19:1 odds.

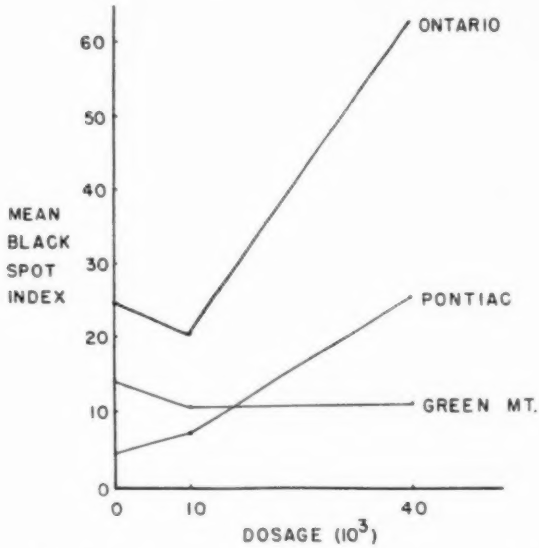

FIG. 2. The influence of gamma irradiation dosage on the mean black spot index.

The results show less black spot, more ascorbic acid and no significant change in glutathione in late planted potatoes compared to the early planting.

The variety results summarized in Table 3 show that black spot was highest in Ontario with no significant difference between Pontiac and Green Mountain. However, the significant variety and dosage interaction shown in Fig. 1 more adequately illustrates the true variety reaction, where Pontiac normally has less blackspot than Green Mountain.

TABLE 3.—*The influence of variety on the mean black spot index, ascorbic acid and glutathione content (mg per 100 grams of fresh tissues) of potato tubers.*

Variety	Black spot index	Ascorbic acid*	Glutathione
Pontiac	13	6.0	7.6
Green Mountain	13	9.1	6.4
Ontario	37	6.5	6.5
			NS

*All varieties significantly different at 99:1 odds.

The greatest difference noted in ascorbic acid was the relatively high levels in Green Mountain, and low but significantly different values for Pontiac and Ontario. Glutathione content was not significantly different among varieties.

The correlation coefficients for the respective laboratory treatments with the incidence of black spot are presented in Table 4.

TABLE 4.—*A summary of the correlation coefficient between the black spot index and the indicated variable.*

Ascorbic acid	Coefficent	Glutathione	Coefficent
All Treatments	-.419*	All Treatments	-.103
Check Treatments	.037	Check Treatments	.022
Irrad. Treatment	-.470*	Irrad. Treatment	.070

*Significant at 99:1 odds.

There is no apparent relationship between glutathione and black spot or between the non-irradiated ascorbic acid content and black spot. However, there is a small, but highly significant negative correlation between black spot and ascorbic acid content. Since the effect is confined to irradiation treatments, no cause and effect relationship to black spot is suggested by these data.

Tyrosinase activity results were variable depending upon how the oxygen consumption is expressed. If expressed on a dry weight basis, gamma irradiation resulted in increased tyrosinase content. However, no effect of irradiation was evident when fresh weight data were used. (Table 5).

TABLE 5.—*The effect of irradiation on the tyrosinase activity of potato tuber tissue. The data are expressed as cubic centimeters of oxygen consumed per gram of fresh or dry weight of tissue per hour.*

Dosage	Dry weight	Fresh weight
0	14.84 cc	2.76 cc
40,000 r	16.97 cc	2.93 cc
	*	NS

*Significantly different at 19:1 odds.

The influence of variety, sampling date and their interactive effects are summarized in Table 6.

Sampling date influences were non-significant regardless of the method of expressing the enzyme activity. Varieties did not differ in tyrosinase activity when compared on a dry weight basis, but when dry matter is not compensated for, Ontario had one-third greater activity.

It is apparent that tyrosinase activity is in part related to the dry matter content of the sample. This is supported by a significant correlation value between total oxygen consumption and dry matter of .344. Tyrosinase activity is correlated to black spot incidence on a fresh weight basis ($r = .541^*$) but not on a dry weight basis ($r = .161^{ns}$).

*Significant at 99:1 odds.

TABLE 6.—*The influence of variety and sampling data on the tyrosinase activity of potato tuber tissue. The data are expressed as cubic centimeters of oxygen consumed per gram of fresh or dry weight of tissue per hour.*

Sampling date	Dry weight[1]			Fresh weight[1]		
	Pontiac[2]	Ontario[2]	Mean	Pontiac[3]	Ontario[3]	Mean
Dec. 15	16.03	14.47	15.25	2.41	3.11	2.75
Jan. 14	15.78	18.92	17.35	2.63	3.51	3.07
Feb. 13	16.74	14.56	15.65	2.56	3.73	3.15
Mar. 14	12.95	16.54	14.75	2.46	3.22	2.84
	15.38	16.12	NS[4]	2.52	3.35	NS[4]

[1]Variety sampling date interaction significant at 19:1 odds.
[2]Varieties not significantly different.
[3]Varieties significantly different at 99:1 odds.
[4]Sampling dates not significantly different.

Discussion

Work over a three year period demonstrated that irradiation increased the incidence of black spot. However, it was not definitely established what minimum dosage is necessary to induce an increase of commercial importance. Under various conditions, dosages as low as 5,000 r and as high as 40,000 r were necessary to initiate the increase. Changes in tuber chemistry which influence susceptibility can vary greatly due to varietal characteristics, climatic conditions, cultural techniques and other possible unknown factors. The results reported here indicate more work should be done to determine the effects of irradiation on tuber quality before a practical application of it's sprout inhibitory properties can be utilized.

Although most of the other data on irradiation and ascorbic acid effects differ from these data, analyzing for ascorbic acid a few days after irradiation gives similar results. (4, 10, 14). Research by Sereno, Highlands, Cunningham, and Getchell (14), indicates that ascorbic acid content is reduced 2 weeks after irradiation and then maintains a fairly constant level for 6 to 7 months at storage temperatures of 38 or 45° F.

Unpublished data by Kelly and Somers, Federal Nutrition Laboratory, Cornell University, show that varieties which have different initial levels of ascorbic acid tend to maintain their relative positions during 200 days of storage. However, varieties high in the vitamin decrease at a more rapid rate than low varieties. Thus, the differences in ascorbic acid between Green Mountain variety and Pontiac and Ontario were probably greater at the time of treatment than those reported.

The highly significant negative correlation between ascorbic acid and black spot incidence indicates that tubers high in ascorbic acid are relatively resistant to increases in black spot. Green Mountain variety can be considered more resistant to black spot increases caused by gamma irradiation because of a high ascorbic acid content.

Such a resistance theory concerning ascorbic acid was proposed by Cooke (4). It was noted that plant species naturally high in ascorbic acid (cabbage) were more resistant to irradiation than species with medium (soybean) or low (xanthium sp.) contents. This is the first time that differences in resistance has been noted within one species of a plant with differences in ascorbic acid levels.

The results concerning the sulfhydryl compounds were in apparent conflict with radiation results showing an oxidation of the sulfhydryl group to disulfide form (1, 2). However, McArdle and Desrosier (7), showed that irradiated protein solutions such as casein and albumen, increased in sulfhydryl groups. These increases were apparently caused by protein degradation. Perhaps the sulfhydryl increase observed in potatoes is actually a measure of protein degradation in the potato tuber induced by irradiation.

Total oxygen consumption by the enzyme tyrosinase, was not affected by irradiation dosage. These data are in agreement with the results of Sussman (18). When the results were expressed on a fresh or dry weight basis different effects were noted. The results suggested a positive relationship between dry weight changes and tyrosinase content. The primary effect of irradiation on tyrosinase was probably reflected through a change in the dry matter content.

Conclusions

Research over a three year period demonstrated that gamma irradiation of potatoes results in increased black spot. Specific dosages necessary to initiate the increase cannot be given because of yearly and variety variations.

Irradiation decreased ascorbic acid content, increased glutathione content and modified the tyrosinase content as the dry matter was affected.

No specific cause and effect relationship could be demonstrated between black spot incidence and the content of ascorbic acid, glutathione or tyrosinase. High levels of ascorbic acid in the Green Mountain variety resulted in natural radio-resistance as measured by irradiation induced increases of black spot.

Literature Cited

1. Barron, E. S. G., and S. Dickman. 1949. Studies on the mechanism of action of ionizing radiations, II. Inhibition of -SH enzymes by Alpha, Beta and Gamma rays. J. Gen. Phys., 32: 395-405.
2. Barron, E. S. G., S. Dickman, J. S. Muntz, and T. F. Senger. 1949. Studies on the mechanism of action of ionizing radiations. I. Inhibition of enzymes by X-rays. J. Gen. Phys., 32: 537-552.
3. Brownell, L. E., J. V. Nehemias and J. J. Bulmer. 1954. Designs for potato irradiation facilities. Eng. Res. Inst. Ann Arbor, Mich.
4. Cooke, A. R. 1953. Effects of Gamma irradiation on the ascorbic content of green plants. Science, 117: 588-589.
5. Duncan, D. B. 1955. Multiple range and multiple f. tests. Biometrics, 11: 1-42.
6. Goddard, D. R. and C. Holden. 1950. Cytochrome oxidase in the potato tuber. Arch. Biochem., 27: 41-47.
7. McArdle, F. J. and N. W. Desrosier. 1955. Influence of ionizing radiations on the protein components of selected foods. Food Tech., 9: 527-532.
8. Nelson, W. L. and G. F. Somers. 1945. Application of the indophenol-xylene extraction method to determination in large numbers of tomato and tomato juice samples. Ind. Eng. Chem. Anal. Ed., 17: 754-756.
9. Owen, J. S., B. Iggo and D. B. Horn. 1954. Use of p-chloromercuribenzoic acid in determination of ascorbic acid in the presence of sulfhydryl compounds. Nature, 174: p. 701..
10. Proctor, B. E. and J. P. O'Mears. 1951. The effect of high voltage cathode rays on ascorbic acid *in vitro* and *situ* experiments. Ind. Eng. Chem. 43: 718-721.
11. Sawyer, R. L., S. L. Dallyn and D. J. Cotter. 1955. Some physiological aspects

of irradiated potatoes, Conf. on Biological, Physical and Industrial Aspects of Potato Irradiation, Unedited report from Biology Department. Brookhaven National Laboratory, p. 13.

12. Sawyer, R. L. and S. L. Dallyn. 1955. The effect of Gamma irradiation on storage life of potatoes. Am. Potato J., 32: 141-143.
13. Scudder, W. T., W. C. Jacob and H. C. Thompson. 1950. Varietal susceptibility and the effect of potash on the incidence of black spot in potatoes. A.S.H.S., 56: 343-348.
14. Sereno, Marco N., M. E. Highlands, C. E. Cunningham and J. S. Getchell. 1957. The effect of irradiation and subsequent controlled storage upon the composition of Maine Katahdin potatoes, Maine Agr. Expt. Sta. Bull. 563.
15. Sparrow, A. H. and E. Christiansen. 1954. Improved storage quality of potato tubers after exposure to Cobalt^{60} Gammas. Nucleonics, 12: 16-17.
16. Sparrow, A. H. and W. R. Singleton. 1953. The use of radiocobalt as a source of Gamma rays and some effects of cronic irradiation on growing plants. The Amer. Naturalist., 87: 29-48.
17. Snedecor, George W. 1950. Statistical methods, 4th Ed., Iowa State College Press.
18. Sussman, Alfred S. 1953. The effect of ionizing radiations upon the respiration and oxidases of the potato tuber. J. of Cellular and Comp. Physiol., 42: 273-283.
19. Waggoner, P. E. 1955. Radiation resistance of tuber to rot. Am. Potato J., 32: 448-450.

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NEWS AND REVIEWS

POTATO PROCESSING AND ITS FUTURE[1]

A. E. Mercker[2]

Potato processing has been going on for centuries. Probably the oldest commercial form of processed potatoes is starch.

Until about 1845, the only form of starch was potato starch. When the blight epidemics hit potatoes throughout the world and sent their price up to about $10.00 a bushel it stimulated researchers to seek other starch material, and a process whereby starch could be made from corn was devised. There was some potato flour manufactured at this time also.

The processing of potatoes for food has been going on for over a century. Potato chips were the first, followed by canned potatoes. Some potato flour and dehydrated potatoes were processed during World War I. The use of potatoes for flour declined after World War I and it was used only in the finest of pastry products and generally by small bakers. The quantity used for potato chips was small, being less than 3 million bushels annually up until about 1935. Up to 1940 less than 1½% of our potato production was processed.

Since 1940 there has been a continuous rise in the quantity of potatoes used for processed foods and a tremendous increase in the end products that are processed. About 21% of the large 1959 crop was processed, and probably 23% of the larger 1960 crop will be processed. The expectation is that about 97 million bushels of potatoes will be used for processing from the 1960 crop. This is a total increase of about 10% over the quantity used from the previous year's crop. (Tables 1 and 2).

Percentagewise, since 1951 production of frozen French fries has increased ninefold, and dehydrated and dried products, other than flour, six times. Potato chips have about doubled. There have been moderate increases in the processing of potatoes for flour and canning, and a larger increase in the use of potatoes for hash, stews and soups.

Per capita consumption declined from 128 pounds in 1940 to 100 pounds in 1951, after which it gradually rose until in 1959 it was up to 110 pounds. The reversal of the downward trend was due to the increase in processing, which accounted for about 12 pounds of the per capita consumption from the 1951 crop and 31 pounds from the 1959 crop. However, consumption of fresh potatoes declined from 126 pounds in 1940 to 83 pounds in 1951 and to a low of 79 pounds in 1959.

It is my belief that the downward trend in the total per capita consumption has been permanently checked and that it will increase largely because of the convenience of preparation of processed products, their dependability as to quality and, last but not least, their attractive profit margins to the processor and handler. To substantiate this viewpoint, the National Food Opinion Panel recently made a survey of 7,618 homemakers in all areas of the Nation, of various ages, income levels and racial groups. They were asked what new foods they would like. Two-

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TABLE 1.—*Prepared by National Potato Council.*
U. S. Production, Utilization and Use of Designated Potato Crops[1,2]

Crop year	1940	1951	1959	1960[7]
	1,000 Bushels			
Production	375,920	326,359	405,400	427,110
Imports	930	2,309	1,190	2,000
TOTAL SUPPLY	377,850	328,668	406,590	429,110
Exports	2,495	6,707	5,358	4,000
Shipments to territories	1,788	1,074	1,840	1,900
TOTAL OFF SHORE SALES	4,283	7,781	7,198	5,900
Available domestic use	373,567	320,887	399,392	423,210
Used for seed	41,985	31,050	34,963	35,000
Fed to livestock—shrinkage & loss[6]	37,238	19,664	35,790	49,000
Starch[6]	8,030	4,701	10,540	16,700
Alcohol[6]	..	..	..	..
TOTAL NON-FOOD USE	87,253	55,415	81,293	100,700
TOTAL FOOD USE	286,314	265,472	318,099	322,510
Military use—Fresh	..	9,900	6,500	6,500
Est. Civilian use	286,314	255,572	311,599	316,000
PROCESSED[3]				
Flour[6]	400	500	2,500	2,500
Dehydration[6,3]	..	2,620	17,000	22,700
Canning	..	1,000	1,500	1,500
Hash, Stews, Soups	500	1,200	2,500	2,500
Frozen French fried	..	2,000	17,530	20,800
Potato chips	4,500	22,760	47,000	47,000
TOTAL PROCESSED	5,400	30,080	88,030	97,000
Est. Sold to restaurants[3]	40,000	59,000	65,000	65,000[4]
Est. Total used fresh in homes	240,914	166,492	158,569	154,000
Used on farms	63,099	24,912	16,250	18,000
Purchased fresh for home use[5]	177,815	141,580	142,319	136,000[5]
Civilian population July 1 (millions)	134.0	153.2	174.5	177.5
Per capita consumption Crop Yr.—Civilian lbs.	128.0	100.1	110.0	107.0
Per capita consumption Cal. Year—Pounds	121.0	108.0	103.0	109.9
Per capita pounds used as foods				
Processed	1.9	11.8	31.0	33.0
Fresh	126.1	83.3	79.0	74.0
Processed per cent of production	1.4	9.5	21.2	22.7

[1]Source: Agricultural Marketing Service except as noted.
[2]Production of August 1960 USDA Crop Report. All other figures in columns are estimates of the NPC Exports-Imports May through April.
[3]Industry estimates.
[4]Includes an estimated 6,000,000 bushels of prepeeled potatoes.
[5]Includes an estimated 85,000,000 bushels packed in consumer-size packages of 25 lbs. or smaller.
[6]Includes quantities processed to starch and flour or fed under the USDA diversion program.
[7]Preliminary.
REVISED August 1960.

thirds of the women requested processors to offer more sizes and varieties of packaged foods, and they especially wanted, among several other items, more instant potatoes and gravy mixes. In other words, we have not fully developed the many new convenient high-quality products that the public wants.

We already have about 20 different types and styles of dried potatoes in various sized packages. We probably have 30 different types of frozen

TABLE 2.—*Processed Potato Products.*

	Crop Years 1955	1956	1957	1958	1959	1960[1]	1961[1]
	Million Pounds Finished Products						
Cubes, Slices, Au Gratin, Scalloped, Shreds, Patties, Etc.	20	14	22	20	30	40	75
Instant Mashed							
Granules	15	20	40	50	70	80	100
Flakes	--	--	--	20	31	40	60
Frozen Prepared Potato Products	175	250	225	330	400	530	700
Potato Chips	590	670	670	700	730	760	800

[1]Estimated

prepared potato products and we have not reached the end yet. Our sales ability has not been fully exerted. About 54% of the frozen prepared potato products are purchased by restaurants, about 50% of the granules are packaged in institutional-sized packages, and probably 25% of the flakes are in institutional sized packages. Potato shreds, dried patties, and slices are just beginning to be introduced to restaurants and hotels.

The production of practically all processed potatoes is being increased, as stated above, the largest increase percentagewise has been in frozen prepared and dehydrated products. In 1951 potato chips comprised 77% of the total of all processed products. This dropped to 53% in 1959 and no doubt will drop below 50% in 1960. In areas where we have a measure of the quantity processed to food we note that of Idaho's 1959 crop 41% was processed, four-fifths of it into food products, the other one-fifth into starch and flour. In addition, 5% was fed to livestock, leaving only 54% for sale in the fresh market or to be used for seed or for food on the farm where produced. In Maine, 15% of the crop was processed; in the Red River Valley 17%; and in Washington 9%. In areas where we do not have a measure of the quantity processed into food, in my judgment, from 20% to 25% of the crops from Pennsylvania, Michigan, Western New York, New Jersey and Ohio are used for processing, mainly for potato chips, and an appreciable quantity is also processed from Wisconsin, Colorado and Utah.

Of the early areas, South Carolina and the Hastings area of Florida sell about 50% of their production to potato chippers. Smaller quantities of the crops from Alabama, North Carolina and Virginia were sold to chip processors. Arizona sold 18% of its 1959 crop to potato chippers. The larger proportion used for processing, and the fact that fresh consumption was good, resulted in higher prices to the grower, so that the 1959 crop sold for an average of $2.27 per cwt., or nearly parity price.

WHERE DO WE GO FROM HERE?

The prospects for further increases for the short-term period (about five years) are good. The processor knows a great deal more about the

food value and good eating quality of potatoes than does the handler of the fresh product. The processor also has close quality control supervision. Therefore, he comes nearer to offering the public a continuous supply of about the same standard high-quality product at all times. The processor has more salesmen under the direction of a single head. The handlers of the processed products are large organizations. They advertise their products, and in 1959 they spent about 14½ million dollars to advertise them, of which about one-half was spent by the instant potato processors. In comparison, only about $305,000 was spent to advertise the fresh potato.

The processor has initiative, good research organization and is developing new types of products that are meeting with popular appeal. The processors can look forward to an increase in the export of their product, with the possible exception of the frozen French fries.

The outlook for the next five years is very good, provided we do not have an appreciable business recession. However, it may be necessary to do more educational work as to how to properly prepare the processed potatoes. This is particularly true of the instant mashed potatoes.

There is always the possibility of the relocation of processing plants to the areas of potato production, particularly to those areas that produce, over a period of years, a quality potato that is suitable for high quality potato chip production.

Storage operations are becoming larger in areas of production with close, efficient storage supervision. In most instances these operators are keen, capable judges of the potato market trends. Potato chip processors in distant producing areas would have the disadvantage of not having close and nearby servicing, but this may be overcome by the proper selection of wholesale food distributors. Jurisdictional labor problems may tend to bring a change in the location of plants and even in the consolidation of interests on the part of processors, producers, and distributors in order to strengthen their position at the bargaining table.

Long-Time Outlook

The development of better varieties for processing and for fresh distribution would be helpful. I. firmly believe that we need more competition in the breeding of varieties for specific uses, and I recommend that this competition be provided for by an amendment to the Plant Patents Act so that the breeder of a new variety would receive the same patent protection that is afforded the breeders of all other agricultural commodities.

The construction of seven new plants this year will provide enough capacity for the next few years. We have not touched the horizon on the consumption of processed products, but our productive capacity may be ahead of our ability to sell and consume. The field is wide open for the dried potato slices, au gratin potatoes, and some other forms that are being developed.

For the long-time outlook, however, we can expect increased competition from overseas potato production. Currently our product is superior and we are expecting some of our dried potato products for use, not

only as table potatoes, but in the processing of meat and vegetable combinations. However, as the processed products of other countries are improved attempts will be made to export them to the United States. We do have the advantage of some tariff protection. Raw material costs are higher abroad, particularly in Western Europe where potatoes are sold to processors on the basis of their solid matter, but they have the advantage of efficient labor at lower wage rates and a ridiculously low water transportation rate to our Atlantic Coast ports when compared with our inland freight rates within the United States.

The immediate outlook is bright, and the fact that we have been able to increase our per capita consumption from 100 pounds to 110 pounds, and the fact that our population has increased, has resulted in the increased use of potatoes for food from 159 million cwt. (265 million bushels) from the 1951 crop to 190 million cwt. (318 million bushels) from the 1959 crop — an increase of about 31 million cwt. or 53 million bushels. There is no one area that is going to capture the processing market, due to the fact that if too large a portion is located in one area the processors expose themselves to the hazards of production, such as weather, diseases and pests, and competition among themselves.

LP-GAS ON THE FARM

An informative booklet for farmers, describing methods of increasing farming profits with liquefied petroleum gas equipment, has been issued by the National LP-Gas Council.

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Copies of this report are available at $1.00 per copy when accompanied by a remittance, $1.25 when invoiced and billed. Address orders to A. B. Groves, Winchester Fruit Research Laboratory, 2500 Valley Avenue, Winchester, Virginia. Make remittances payable to the American Phytopathological Society.

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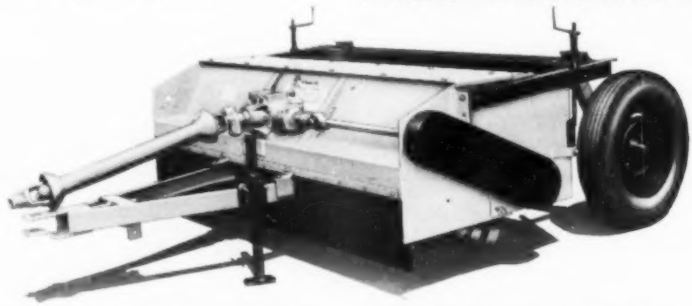

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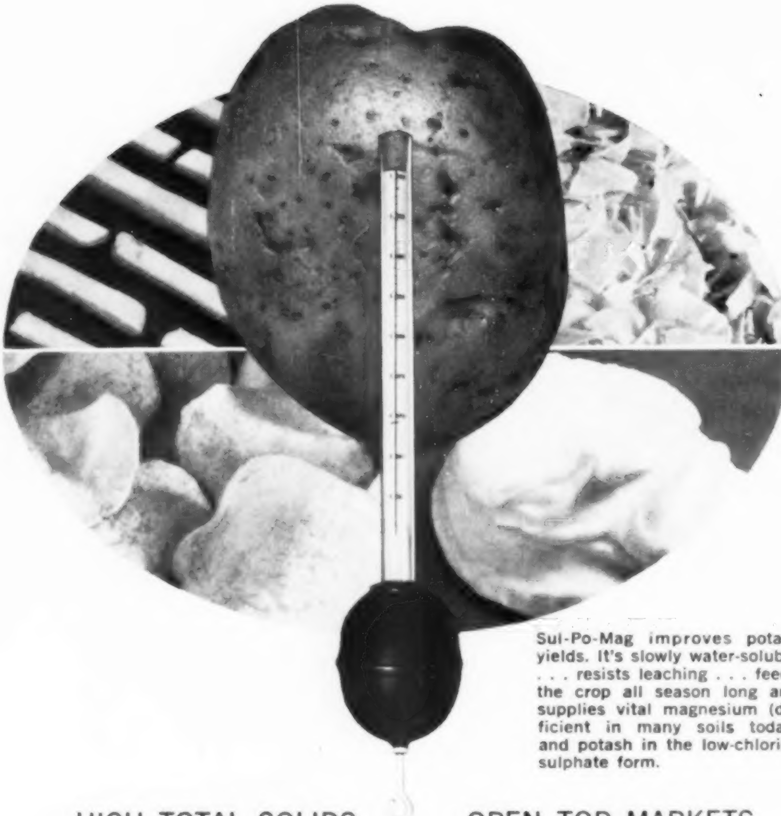

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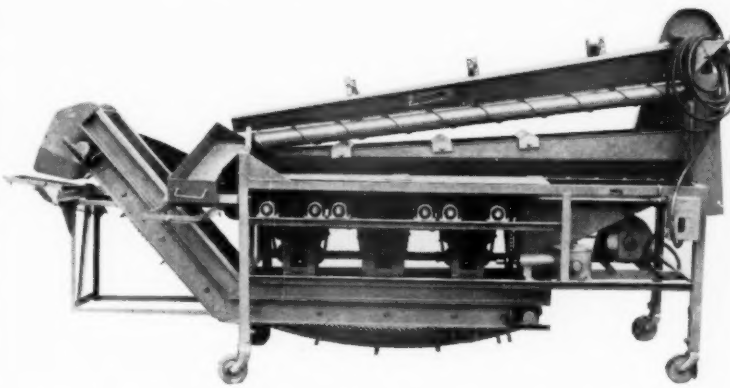

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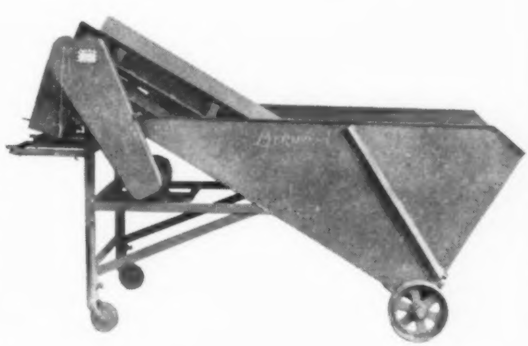

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